

LANDSAT DATA CONTINUITY MISSION
OPERATIONAL LAND IMAGER
STATEMENT OF WORK

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LDCM PROJECT
DOCUMENT CHANGE RECORD

Sheet: 1 of 1

REV

LEVEL

DESCRIPTION OF CHANGE

APPROVED

BY

DATE

APPROVED

List of TBDs/TBRs

Item No.

Location

Summary

Ind./Org.

Due Date

Resolved Date

2

Applicable Documents

Document Numbers for all LDCM documents

LDCM

RFP release

4

6.2

Contract clause number for Anomaly Support task

LDCM

RFP release

5

7

Contract clause number for Optional Extended Support

LDCM

RFP release

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Introduction

The Landsat Data Continuity Mission (LDCM) is the successor mission to Landsat 7. Landsat satellites have continuously acquired multi-spectral images of the global land surface since the launch of Landsat 1 in 1972. The Landsat data archive constitutes the longest record of the land surface as viewed from space. The LDCM mission objective is to extend the ability to detect and quantitatively characterize changes on the global land surface at a scale where natural and man-made causes of change can be detected and differentiated. The Operational Land Imager (OLI) is the reflective-band science data-producing sensor for the LDCM.

Scope

This Statement of Work (SOW) defines the minimum effort required of the Contractor for the design, engineering analyses, development, fabrication, integration, algorithm development, test, evaluation, delivery, and support for the Operational Land Imager (OLI) instrument, a portion of the Landsat Data Continuity Mission. The Government is responsible for integration of the LDCM. Figure 1 is a block diagram of the LDCM segments and elements, and their interfaces for reference. The Contractor provides support for the OLI-related portions of the Government's mission system integration effort.

This Statement of Work requires delivery of one OLI instrument, which consists of the multi-band instrument, the Solid State Recorder, the harnessing between the multi-band instrument and the Solid State Recorder, and the harnessing between the OLI and the spacecraft bus. The OLI shall meet the requirements of the OLI Requirements Document (OLIRD) and the LDCM Interface Requirements Document.

The interface design of the OLI to the spacecraft will be refined very early after OLI contract award through trade study interaction with potential spacecraft bus contractors, and through OLI contractor participation in development of the OLI interface requirements for the spacecraft bus procurement. After a spacecraft bus contractor is selected, the spacecraft contractor will assume primary responsibility for leading development of the OLI-to-spacecraft interface control documentation in coordination with the OLI contractor. If a separate thermal sensing instrument (generally referred to as the Thermal Infrared Sensor (TIRS)) is included in the LDCM mission, OLI interface design, development, and documentation will also appropriately address TIRS interfaces and involve interaction with the TIRS developer.

FIGURE 1
LDCM SEGMENTS, ELEMENTS, AND INTERFACES
Definitions

The following definitions apply to this document:

Operational Land Imager (OLI) ñ For the purposes of this document, the term OLI refers to the multi-band sensor, the Solid State Recorder, and the harnessing between the two.

Contractor ñ The developer of the item of reference. If the term contractor is used in this document without specific reference to an item (e.g., OLI, spacecraft bus, TIRS, etc.), then the term shall be interpreted to imply the OLI contractor. In all cases, the term contractor also implies any and all associated suppliers and subcontractors.

Shall ñ Compliance by the Contractor is mandatory. Any deviations from these contractually imposed mandatory requirements require the approval of the contracting officer.

May ñ At the discretion of the Contractor or Government.

Will ñ Designates the intent of the Government. Unless required by other contract provisions, noncompliance with the will requirements does not require approval of the contracting officer and does not require documented technical substantiation.

Engineering Peer Review (EPR) ñ a meeting between approximately 2 to 5 Government representatives and Contractor technical representatives to provide focused, in-depth technical reviews that support the evolving design and development of a product subsystem or discipline area. The purpose of an EPR is to add value and reduce risk through expert knowledge infusion, confirmation of approach, and specific recommendations. An EPR provides a penetrating examination of design, analysis, manufacturing, integration, test and operational details, drawings, processes and data.

Technical Interchange Meeting (TIM) ñ an informal meeting, between the Contractor and approximately 5 to 10 Government representatives, and/or the spacecraft and MOE contractor personnel to discuss a system process or feature. For example, to reach understanding of an operation or analysis, presentation of test results, discuss planned interface changes, plan for an upcoming test, etc. TIMs typically are held at the contractorís facility and typically run no more than two days. TIMs involving the OLI contractor may be also be conducted at the spacecraft or MOE contractorsí facilities. Actions are informally tracked by the TIM organizer.

Major Review ñ Major reviews are major milestones in the implementation where information is formally presented to a panel of Government experts and external reviewers. DRs can involve up to approximately 30 Government representatives and typically run up to four days. Formal action items are logged and tracked by the Project Office.

Applicable Documents

The documents listed in this section apply directly to the performance of the OLI Contract. These documents establish detailed specifications, requirements, and interface information necessary for the performance of the contract. In case of conflicting requirements, the order of precedence of documents not specifically called out in the Contract is: this Statement of Work, the Instrument Mission Assurance Requirements document, the OLI Requirements Document, the LDCM Interface Requirements Document, the Contract Data Requirements List, and the LDCM Environmental Verification Requirements.

Operational Land Imager Requirements Document: Document Number 427-XXX (TBD 2)

Special Calibration Test Requirements: Document Number 427-XXX (TBD 2)

Operational Land Imager Contract Data Requirements List: Document Number 427-XXX (TBD 2)

LDCM Interface Requirements Document†: Document Number 427-XXX (TBD 2)

Instrument Mission Assurance Requirements: Document Number 427-XXX (TBD 2)

LDCM Environmental Verification Requirements: Document Number 427-XXX (TBD 2)

LDCM Acronym List and Lexicon: Document Number 427-XXX (TBD 2)

Top of Atmosphere Radiance Values, MODTRAN 4 Model. <http://ldcm.nasa.gov/>

NIST 2000 realization of scale of spectral irradiance, H. W. Yoon, C. E. Gibson and P. Y. Barnes, The realization of the NIST detector-based spectral irradiance scale, *Metrologia* 40 (2003) S172–S176.

Landsat Worldwide Reference System-2 (WRS-2) Definition, February 9, 2006

Criteria for Flight Project Critical Milestone Reviews, GSFC-STD-1001, February 2005

Government-provided Work Breakdown Structure, Document Number 427-xxx (TBD 2)

NPR 2810.1, Security of Information Technology
Reference Documents

LDCM Operations Concept, 427-XXX (TBD 2)

Work to be Performed

This section, along with the Contract Data Requirements List (CDRL) document 427-XXX (TBD 2), describes the specific work to be accomplished by the OLI instrument Contractor. In accordance with the requirements of this document, the contract, all associated requirements documents, and the other attachments and applicable documents to this contract, the Contractor shall provide the personnel, materials, equipment, and facilities necessary for the successful and on-time implementation of the design, analysis, development, fabrication, assembly, test, engineering data analyses, calibration, qualification, delivery, support to Observatory Integration and Test, support to mission level activities, and sustaining engineering of the OLI.

The Contractor shall deliver to the Government an OLI that is fully tested, calibrated, and has demonstrated compliant and reliable operation in accordance with the requirements of this contract.

Management

Project Management

The Contractor shall maintain a project office to manage the technical activities and resources of the OLI project. The Contractor shall appoint a dedicated Project Manager to direct and manage the OLI project. The Contractor's Project Manager shall have responsibility for the overall technical performance, resource management, and schedule management of the contractual effort and all subcontracts. The Contractor's designated Project Manager shall report to a level of company management appropriate to ensure prompt resolution of all problems.

The Contractor shall prepare a Project Management Plan and a Final Report in

accordance with CDRL PM-11 and CDRL PM-4, respectively.

Government Oversight

The Contractor shall open to Government attendance all Contractor and subcontractor internal data, reviews, audits, meetings and other activities within the scope of the contract. For access and insight activity, iGovernment includes Government personnel and Government contractor personnel. The Contractor shall allow and enable the use of Non-Disclosure Agreements with Government contractors where appropriate. The Contractor shall notify the Contracting Officer, the Government Resident Office and the Contracting Officer's Technical Representative (COTR) of meetings, reviews or tests in sufficient time to permit meaningful Government participation.

Reviews and Meetings

The reviews listed in this section should not be considered a comprehensive set of reviews for the Contractor's program. Additional reviews that the Contractor deems necessary to successfully execute the program may be conducted at the Contractor's discretion. The Contractor shall notify the Government at least 10 working days in advance of lower level Contractor subsystem reviews to allow the Government time to attend the review as part of its insight activities.

Major Reviews

All major reviews will be convened and review boards appointed and chaired by the Government. The Contractor shall demonstrate compliance with the review success criteria of GSFC-STD-1001, Criteria for Project Flight Critical Milestone Reviews, as applicable to spaceflight instruments. The Contractor shall respond as required to action items assigned by the Government. The Contractor work with the Government project and review team an additional day following all reviews to discuss and address issues raised and actions assigned at the reviews. The Government will convene a delta review if the success criteria for a review are not met to the Government's satisfaction. The Contractor shall prepare and present their portion of these reviews, as appropriate.

Instrument Reviews

The Contractor shall host, prepare and present the following instrument reviews and provide review packages in accordance with the stated CDRL. If multiple imaging sensors are developed to meet the requirements of this contract, then the Contractor shall conduct the following reviews for each sensor.

Instrument System Requirements Review (ISRR), CDRL RE-1

Instrument Integrated Baseline Review (IIBR), CDRL RE-8 (See para. 1.9)

Instrument Preliminary Design Review (IPDR), CDRL RE-2

Instrument Critical Design Review (ICDR), CDRL RE-3

Instrument Pre-Environmental Review (IPER), CDRL RE-4

Instrument Pre-Ship Review (IPSR), CDRL RE-5

The Contractor shall assume that each review requires four days to complete. The Contractor shall host and work with the Government project and review team an additional day following all instrument reviews to discuss and address issues raised and actions assigned at the reviews. The Government will convene a delta review if the success criteria for a review are not met to the Government's satisfaction. The Contractor shall host these delta reviews, and prepare and present these reviews.

Spacecraft Reviews

The Contractor shall participate in and support the spacecraft contractor in preparation for the following spacecraft reviews:

- Spacecraft System Requirements Review (SSRR)
- Spacecraft Preliminary Design Review (SPDR)
- Spacecraft Critical Design Review (SCDR)

The Contractor shall assume four days of attendance at the spacecraft contractor's facility for each review and shall present a subset of the Instrument SRR, PDR, and CDR, respectively (updated as appropriate), with emphasis on instrument interfaces to the spacecraft.

Mission Operations Element Reviews

The Contractor shall participate in and support the MOE contractor in preparation for the following Mission Operations Element (MOE) reviews:

- MOE Requirements Review
- MOE Preliminary Design Review
- MOE Critical Design Review

The Contractor shall present instrument command and telemetry information and other material as appropriate. The Contractor shall assume four days of attendance at each review at the MOE contractor's facility.

LDCM Mission Level Reviews

The Contractor shall prepare and present a portion of Mission Level reviews and provide their portion of the review packages in accordance with CDRL RE-6:

- Mission Definition Review (MDR)
- Preliminary Design Review (PDR)
- Critical Design Review (CDR)
- System Integration Review (SIR)
- Pre-Environmental Review (PER)
- Pre-Ship Review (PSR)

The Contractor shall prepare and present a portion of the On-Orbit Acceptance Review in accordance with CDRL RE-9.

The Government leads these Mission-level reviews and will also be presenting material at Mission Level reviews. The Contractor shall support the Government in developing the algorithm development portion of the Mission Level reviews. The Contractor shall respond to action items as requested by the Government. The Contractor shall participate in dry runs of all Mission-Level Reviews with the Government approximately one week in advance of the reviews. The Contractor shall assume that the Mission-level reviews will take four days and that dry runs will take two days.

The Contractor shall also attend and support as necessary the following additional Mission-Level Reviews:

- Mission Operations Review (MOR)
- Flight Operations Review (FOR)
- Operational Readiness Review (ORR)
- Flight Readiness Review (FRR)
- Launch Readiness review (LRR)
- Post-Launch Assessment Review (PLAR)
- Critical Event Readiness Review (CERR)

It is expected that these additional reviews require a lesser degree of preparation and participation by the instrument contractor than the other Mission-Level Reviews.
Engineering Peer Reviews

The Contractor shall define and implement a set of Engineering Peer Reviews (EPRs) for the hardware and software subsystems of the OLI instrument commensurate with the scope, complexity and acceptable risk of the product. The Contractor shall submit the Engineering Peer Review Plan in accordance with CDRL PM-5.

The Contractor shall chair and host EPRs at the Contractor's facilities with Government participation on the review panels. The Contractor shall document EPRs in accordance with CDRL RE-7, Engineering Peer Review Data Packages. The Contractor shall systematically and comprehensively peer review the product at the individual subsystem level, and at component (iboxi) and lower levels of assembly, as appropriate. In addition, packaging reviews shall be conducted on all electrical and electromechanical components in the flight system. Subsystem and component level design reviews (e.g., Telescope Critical Design Review (CDR), Calibration Assembly CDR, etc.) are considered to be EPRs and subject to this procedure. The Contractor shall conduct multiple peer reviews, as appropriate, over the lifecycle of each subsystem and component, with content consistent with the evolving design and development. As a minimum, the Contractor shall complete a comprehensive set of subsystem or lower-level peer reviews prior to instrument PDR and again prior to instrument CDR. Successful completion of these Pre-IPDR and Pre-ICDR EPRs and resolution of associated technical issues and actions is considered to be an important precursor step in the formal review process. The Contractor shall also use EPRs for the focused evaluation of concepts, designs, plans and processes associated with combinations of subsystems and system functions that cross

traditional subsystem or discipline boundaries. Examples include fault detection and correction; or solutions to address, for example, pointing, thermal or contamination constraints.

Requirements for Software Peer Reviews are covered in a subsequent section of this SOW.

In addition to other standard discipline EPRs, the Contractor shall, as a minimum conduct EPRs to cover the following specific items:

Sensor focal plane assembly

Sensor data system, including the allocation of functions between the sensor and solid state recorder

Algorithm development

Mechanism design and test procedures

Optomechanical design and alignment processes

Sensor calibration design and test

Instrument integration and test (I&T)

Observatory-Level I&T

Fault detection and correction

Flight software development

Command and control procedures

The Contractor shall track action items from EPRs and maintain EPR presentation and closure documentation for the duration of the contract.

Other Reviews and Meetings

In addition to the established meetings required in this section, the Contractor shall support routine informal meetings and telecons with the Government as necessary.

Scheduled Weekly Telecons

In addition to other informal communications, the Contractor shall participate in a scheduled weekly telecon with the LDCM Project Office to communicate status, issues, and schedule progress and plans of the overall contract effort. The Contractor shall distribute meeting minutes, including the action item log, and other documentation as required. The minimum Contractor attendance shall consist of the Project Manager and Systems Manager or the appropriate technical lead managers as required. The Contractor shall provide detailed status, description of issues, and schedule updates for each major element of the contract.

Monthly Project Status Reviews

The Contractor shall communicate the status of the technical effort, program schedule, and resource condition to the LDCM Project on a monthly basis. The Contractor shall conduct Monthly Project Status Reviews (MPSRs), including a presentation package, in accordance with CDRL PM-1. The MPSR shall include Integrated Master Schedules (IMS) prepared in accordance with CDRL PM-2. The MPSR shall be conducted face-to-

face at the Contractor's site unless otherwise agreed to in advance. The Contractor shall host and participate in splinter meetings with the Government for one additional day immediately following MPSRs, if required.

Technical Interchange Meetings and Working Groups

The Contractor shall inform the Government at least one week in advance of Contractor-initiated technical interchange meetings.

The Contractor shall participate in Government-led working groups. At the time of the writing of this document, planned Government-led working groups likely requiring OLI Contractor participation include a calibration/validation group, a systems engineering group, an integration and test group, a mission operations group, a safety working group, a reliability working group. The Contractor shall assume for planning purposes participation in up to six working groups, each requiring support equivalent to two person-days per month.

Status and Planning Meetings

The Contractor shall notify and allow the Government access to Contractor status and planning meetings, including daily stand-ups and tag-ups.

Focal Plane Array Status Telecon

The Contractor shall conduct a weekly telecon and occasional face-to-face meetings with the focal plane array contractor(s) and the Government. The weekly FPA status telecon shall cover: schedule and technical status of FPA development, manufacturing status, qualification and test status, issues and concerns.

Action Item Tracking

The Contractor shall develop and apply a process for capturing and responding to action items assigned by the Government. Instrument milestone reviews, as defined above, are not complete until actions are complete or, at the discretion of the Government, a detailed plan for closure is submitted and approved by the Government.

Electronic Access

The Contractor shall provide to the Government and Government contractor personnel, for review purposes, access via remote desk-top computer to a secure restricted-access general purpose LDCM-specific electronic library. This library shall contain all completed reports, analyses, requirements documentation, internal technical memoranda, change requests and documentation, CDRLs, and all other LDCM-specific documents prepared by the Contractor. Within the library the Contractor shall maintain an index of the material (updated monthly) and a search engine for document access. The non-CDRL material contained in these electronic databases may be in Contractor format. The Contractor shall make the contents of the electronic library remotely downloadable. The Contractor may include engineering drawings in this library, but if not, the Contractor shall provide some other storage/retrieval arrangement.

Internal Technical Memoranda

The Contractor shall provide all OLI-relevant technical internal memoranda as requested by the Government in accordance with CDRL SE-2, Contractor Generated Internal Technical Information. The correspondence may be informal to preserve timeliness. The Government shall have access to these memoranda on a timely basis via hard copy or the electronic library described in Section 1.4.

Access to Controlled Facilities

The Contractor shall obtain all required access authorizations and submit any paperwork required for the Contractor to access Government controlled facilities, such as the Mission Operations Center, and contractor controlled facilities, such as the spacecraft and MOE contractorsí facilities. The Contractor shall allow access by the Government to all Contractor facilities used by OLI.

Risk Management

The Contractor shall establish and maintain a comprehensive risk management program in accordance with the Instrument Mission Assurance Requirements (MAR). The Contractor shall deliver a Risk Management Plan in accordance with CDRL PM-12. The Contractor shall generate a top risk report that is presented and reviewed at all Monthly Project Status Reviews (MPSRs). The Contractor shall provide an estimate of the potential cost impact if risks were to become real problems. The Contractor shall invite the Government to attend Contractor Risk Management Board meetings.

Problem tracking

The Contractor shall develop a closed-loop problem tracking process that includes problem or anomaly reporting, problem analysis, and corrective action. The process shall include: a protocol to review past performance to determine the incidence of identical or related anomalies, an escalation procedure (to inform higher levels of management and the Government) based on mission criticality, and a closeout process for root cause determination, anomaly mitigation, and recurrence control.

Resource Management

The Contractor shall establish, implement, and maintain a comprehensive resource management system for planning, authorizing, and controlling the total resources effort for each task and for providing timely and adequate visibility into manpower and schedule performance. The system shall be consistent with the Contractorís standards.

The Contractor shall implement an Earned Value System (EVS). The Contractor shall provide an Earned Value System Management Plan in accordance with CDRL PM-6. The EVS may be implemented in accordance with the Contractorís standard plans and policies, provided it conforms to the minimum reporting requirements of NPR 9501.2D NASA Contractor Financial Management Reporting, including use of NASA Form 533 reports. The Contractor shall provide Financial Reports and Cost Performance Reports to

the Government in accordance with CDRLs PM-7 and PM-8 and the contractor's standard policies and procedures. The Contractor shall conduct an Integrated Baseline Review at the Contractor facility and present data in accordance with CDRL RE-8. The Contractor shall provide technical and cost data as requested to support the Government's development and updating of the Project Cost Analysis Data Requirement (CADRE) in accordance with CDRL PM-3, CADRE Data.

The Contractor shall establish, implement, and maintain an integrated scheduling system consistent with their corporate procedures and documented in a schedule management plan. The Contractor shall provide and maintain an Integrated Master Schedule in accordance with CDRL PM-2.

The Contractor shall provide the necessary resources for monitoring, controlling, executing, and administering the OLI contract and subcontracts to ensure compliance with all contractual requirements.

Configuration Management

The Contractor shall perform configuration management (CM) in support of the OLI project. The Contractor shall develop and deliver the Hardware and Software Configuration Management Plan in accordance with CDRL PM-10. The Contractor shall notify the Government of CCB meetings and allow Government participation at all CCB meetings. The Contractor shall maintain configuration of deliverable items throughout all phases of assembly and test. The Contractor shall perform and document configuration verification as assemblies are incorporated into higher-level assemblies and at major Project milestones (e.g., pre-environmental test, pre-ship, pre-launch, etc). The CM system shall have a change classification and impact assessment process that results in Class 1 and Class 2 Configuration Change Requests (CCRs) being forwarded to the LDCM Project in accordance with CDRL SE-1, Engineering Change Requests, Deviations, and Waivers. Class 1 changes are defined as changes that impact mission science and performance requirements, system safety, cost, schedule, single point failures, and external interfaces. All other changes are considered to be Class 2 changes. The Contractor shall submit for Government consideration a waiver or deviation for any flight item that is found to be non-compliant with the requirements of the contract Statement of Work (SOW) or the MAR and is not reworked to be compliant, or is not replaced with a compliant item.

The Contractor shall prepare and provide the following configuration control documentation:

Configuration Control Board (CCB) status shall be reported at the Monthly Project Status Review in accordance with CDRL PM-1.

Engineering Drawings in accordance with CDRL SE-5.

The Configuration Item Identification List (CIIL) and the Computer Software Configuration Items (CSCIs) in accordance with CDRL SE-8.

Government Resident Office Support

The Contractor shall provide facilities to support two Government in-plant representatives at the instrument development/build site, including office space, furniture, facsimile machine, office supplies, file/storage area, telephones, network access to the Contractor's electronic database, and access to a copier and a dedicated conference room from contract award through observatory on-orbit acceptance. The Contractor shall provide within these offices high-speed (broadband) internet access and access to an ISP (Internet Service Provider) outside the Contractor's facility to allow for access to the GSFC and USGS network. The Contractor shall accommodate the two in-plant representatives in securable offices.

The Contractor shall provide additional work space, furniture, phones, and high-speed internet access with access to an outside ISP for an additional two visiting Government representatives from contract award through observatory on-orbit acceptance.

Systems Engineering

The Contractor shall perform systems engineering to support the design, engineering analyses, development, fabrication, integration, algorithm development, test, evaluation, delivery, spacecraft integration and test, and on-orbit support for the OLI. The Contractor shall ensure that the OLI meets all contract requirements. The systems engineering effort shall be on-going through all stages of the OLI program, including the allocation of the system performance specification, instrument design, development, fabrication, qualification and acceptance testing, interface with the LDCM spacecraft, support to launch operations, launch, post launch checkout, on-orbit anomaly resolution and support to system operations.

The systems engineering effort shall include analyses of technical requirements and allocation of derived requirements, definition and maintenance of all interfaces, overview of OLI design and verification of all defined and derived requirements, systems analyses and special studies as required, risk management support, and tradeoff analyses. This shall include but not be limited to the following specific activities:

- a. Providing technical direction and oversight throughout all phases of the program.
- b. Supporting all peer reviews, project milestone, gateway and launch reviews, and program status reviews as defined in section 1.2.
- c. Performing all necessary system studies and trades and risk assessments necessary to develop the OLI design.
- d. Performing all necessary coordination, studies and analyses required to interface the OLI to the LDCM spacecraft, including OLI-specific support to ground system requirements development.

Requirements Analyses and Allocations

The Contractor shall provide the definition, allocation, and traceability of system and subsystem requirements and the verification approach.

The Contractor shall conduct complete analyses and simulations in support of technical requirements compliance demonstrations to fully establish, define, maintain, and control budget allocations for all required performance and design parameters. Budget allocations shall include, but not be limited to, mass properties, power, alignment, line-of-sight pointing, contamination, and on-board processor resources.

Tasks include the following as a minimum:

Flow-down of OLI system requirements.

Developing the Instrument Operations Concept in accordance with CDRL SE-14
Maintaining and controlling critical OLI technical performance metrics and margins, and
the other budgets and Key Technical Parameters which are reported at the Monthly
Program Status Review.

Defining the number and hierarchy (sub-modes) of the various instrument operating
modes.

Developing the Beginning of Life (BOL) design performance requirements given that the
requirements of the OLI Requirements Document are for End of Life (EOL) and
documenting the supporting analyses in CDRL SE-31, OLI Performance Margin
Analyses.

Interface Definition, Verification and Control

The Contractor shall meet the interface requirements of the LDCM Interface
Requirements Document. The Contractor shall provide Inputs to the Instrument to
Spacecraft Interface Control Document (ICD) in accordance with CDRL SE-13. The
Contractor shall maintain the ICD, verify the Contractor-supplied sides of the interfaces,
and coordinate with the Government on verification of the spacecraft side of the
interface. The Contractor shall transfer maintenance of the Instrument to Spacecraft ICD
to the spacecraft contractor at a time specified by the Government, but no later than
spacecraft PDR. The Contractor shall continue to support ICD maintenance after
document handover to the spacecraft contractor.

If TIRS is included in the LDCM mission, the OLI Contractor shall lead the development
of the OLI to TIRS Interface Control Document (ICD) in coordination with the TIRS
developer and the Government, and in accordance with CDRL SE-15. The Contractor
shall maintain the ICD, verify the Contractor-supplied sides of the interfaces, and
coordinate with the Government and TIRS developer on verification of the TIRS side of
the interface

The Contractor shall perform necessary analyses and participate with the Government in
the further definition of OLI to spacecraft interfaces, including but not limited to the
following:

Data Volume

Data Interface (data handling, modes, compression)

Mechanical Interface

Thermal Interface
Electrical Interface
ACS Sensors Accommodation/Pointing/Stability/Alignment/Co-alignment/Allocations
Fields of view
Test Planning (as relates to spacecraft requirements)

The Contractor shall participate in the form of meetings, telecons, and reviews, providing comments on analyses and reports, and providing independent analyses.

It is the Government's intention to issue trade study contracts with several spacecraft contractors prior to spacecraft bus selection. During this trade study period, there is an opportunity to more firmly establish interface requirements between the spacecraft and the instrument. To this end, the Contractor shall document and provide the latest instrument interface estimates in accordance with CDRL SE-11, Instrument Interface Information. The Contractor shall then support the Government in answering spacecraft interface questions from the study vendors.

Design and Performance Verification

The Contractor shall address the total system design including performance margins and design approaches to assure achievement of the required instrument life, operations concept, design integrity, failure modes, intra-system and inter-system compatibility, reliability and maintainability, producibility, safety, survivability, training, and testability.

The Contractor shall develop and maintain all necessary plans and procedures to verify that the OLI meets all requirements described in the OLI Requirements Document and the LDCM IRD. The Contractor shall develop and deliver the Specification Tree in accordance with CDRL SE-12. The Contractor shall also perform and document all analyses of the data and information from the design, development, qualification testing, acceptance testing, compatibility testing, and on-orbit testing of the Contractor's hardware and software which are required to ensure that the OLI program will meet its specifications and objectives. These tasks include, but are not limited to the following:

Preparing and maintaining the System Performance Verification Plan and Matrix (CDRL SE-6) for use at the component, subsystem, and instrument levels of assembly, and including spacecraft integration and interface verification.

Analyzing and making available for inspection the required lower-level design specifications in order to meet higher-level performance requirements (e.g., what detector D* should be specified in order to meet system Signal to Noise Ratio). All such analyses shall be identifiable and accessible for Government review.

Preparing and maintaining verification test procedures for use at the component, subsystem, instrument, and observatory level of assembly, including instrument-to-spacecraft integration and interface verification.

Providing the necessary effort and support systems for data reduction and analysis during component and subsystem testing, instrument-level testing, interface verification, spacecraft-level testing, and during on-orbit testing.

Preparing documentation and providing necessary support for reviews defined in section 1.2.

Performing systems engineering and analysis in support of instrument tests at the Observatory level and launch site.

Supporting system level technical interface meetings, including technical issue resolution, performance verification plan buy-offs, pending configuration change requests (CCRís), CDRL data submission review/approval status, test data review, anomaly resolution activities, and test support planning.

Developing and delivering the Calibration/Validation Plan in accordance with CDRL CV-1.

Conducting test evaluation and test reporting.

Providing an Instrument Users Manual in accordance with CDRL OO-2.
Systems Analyses

The Contractor shall, in coordination with systems engineering activities, perform the necessary systems engineering analyses to assure that all requirements of this contract are accomplished successfully and on time. These systems engineering analyses shall include, at a minimum, the following;

Visible and infrared radiometry

Spectral performance

Perform a flowdown of the performance requirements to the Focal Plane Array (FPA), and an analysis of the FPA design to demonstrate that the FPA will be able to meet its requirements with margin.

Optics, including stray light (including stray light from spacecraft and reflected off solar diffuser)

Line of sight jitter, including contributions from both the instrument and spacecraft
Pointing knowledge error budget of the entire instrument and spacecraft (Observatory) system

Data system throughput, storage, and playback analyses

Analysis of polarization sensitivity, how to minimize, achieve, and demonstrate

Analysis of beam alignment design, tolerances and error budget

Analyses of CPU loading, input and output loading, disk utilization, and memory loading for all ADPE.

Structural Thermal Optical Performance (STOP) analysis of the instrument and review and comment on STOP analysis performed for the Observatory.

These and all other analyses performed by the Contractor under this contract shall be available to the Government for review.

Trending

The Contractor shall establish a method for trending test data during instrument and Observatory level testing. The trending method may be different for instrument level testing versus observatory level, but the preferred method at observatory level is to utilize the Government-provided operational trending system. The Contractor shall coordinate with the Government the selected list of parameters to be trended in accordance with CDRL SE-3, Trend Analysis and Operations Log. The Contractor shall monitor selected

parameters for trends starting at the beginning of instrument electrical integration and continuing during the system integration and test phases through the on-orbit commissioning phase. The Contractor shall analyze the trended data for indications of anomalous conditions and for possible performance or reliability degradation. The Contractor shall provide Trending Reports and operating hours in accordance with CDRL SE-3, Trend Analysis and Operations Log. The Contractor shall use the operational trending system to perform trending on orbit. The Contractor shall coordinate with the Government the list of parameters to be trended on orbit using the operational system. The Contractor shall support the development and validation of the Mission Operations Element operational trending system by participation in telecons and review and comment on documentation.

The Contractor shall present a matrix of the components being trended at the IPER. The Contractor shall present the trend data during the IPSR and PSR. Additionally, during the IPER, the Contractor shall define for each parameter trended how the data are analyzed and interpreted with respect to the allowable test limits of the data as the testing progresses through the test phases. Any anomalous changes and/or trend(s) in the data shall be explained during the IPSR and PSR. The Contractor shall establish a system for recording and analyzing the parameters as well as any changes from the nominal even if the levels are within specified limits. The Contractor shall review trending results with the Flight Operations Team prior to launch.

Special Studies

The Contractor shall conduct, in addition to the requirements specified in this document and the contract, additional engineering studies, tests, technical analyses, reviews of test results, design modifications, and tasks relating to the development, implementation, characterization, and operation of the OLI, as authorized by the Government and in accordance with Contract Clause C.2. Each task will be initiated by written direction from the Government contracting officer. The Government will coordinate with the Contractor to define each task in detail, and establish manpower ceilings, performance schedules, and deliverables.

Mission Assurance

The Contractor shall develop, implement, and maintain a comprehensive mission assurance program which meets the requirements of the Instrument MAR (427-XXX) (TBD 2). The Contractor shall adhere to the requirements of the MAR, perform all tasks required by the MAR, and deliver all documents and data required by the MAR.

LDCM Instrument Development

The Contractor shall develop and deliver the OLI in accordance with all contract requirements.

Design Engineering

The Contractor shall develop and deliver the Instrument Design Specification for the OLI in accordance with CDRL SE-9.

Algorithms and Mathematical Models

The Contractor shall develop algorithms and mathematical models as defined below.

Calibration Algorithms and Parameters

The Contractor shall develop and deliver Calibration Algorithms and Parameters in accordance with CDRL CV-6.

Radiometric Math Model

The Contractor shall develop, deliver, and maintain a Radiometric Math Model in accordance with CDRL CV-4.

Line-of-Sight Processing Algorithms

The Contractor shall demonstrate that the end-to-end requirements of section 5.7 of the OLI Requirements Document are satisfied by these algorithms. The Contractor shall document and deliver the results of the demonstration in accordance with CDRL CV-6, Calibration and Algorithm Parameters.

Optical Analytical Model

The Contractor shall develop, deliver, and maintain an Optical Analytical Model in accordance with CDRL CV-5. The Contractor shall verify the accuracy of the model with hardware testing. The Contractor shall update the model to agree with the test results.

Stray Light and Ghosting Model

The Contractor shall develop and maintain the Stray Light and Ghosting Model in accordance with the Special Calibration Test Requirements document (427-XXX) (TBD 2) and make the model available for review at the Contractor's facility. Starting at ICDR, the Contractor shall notify the Government of revisions to the Stray Light and Ghosting Model and make these revisions available for Government review at the Contractor's facility.

Structural Math Models

The Contractor shall develop and deliver Structural and Dynamic Models and Model Verification Plan in accordance with CDRL SE-16. The Contractor shall verify the accuracy of the models with dynamic test data. The Contractor shall update the models to agree with the structural test results.

Thermal Math Model

The Contractor shall develop and deliver Thermal Math Models in accordance with CDRL SE-4. The Contractor shall deliver a Thermal Analysis Report in accordance with CDRL SE-17.

Data Processing Algorithms

The Contractor shall develop, deliver, and maintain Data Processing Algorithms (see OLI

Requirements Document, Section 5 in accordance with CDRL CV-7.

Support to Operational Algorithm Development

The Contractor shall support the development of the operational algorithms to be used in Government LDCM operational data processing. The Contractor shall review and comment on Government algorithm implementation and testing. The Contractor shall assist in reconciling differences between Contractor-derived algorithm results (CDRL CV-7) and Government-derived algorithm results. The Contractor shall participate in TIMs and telecons as part of this effort.

Engineering Development Unit

The Contractor shall develop and deliver an OLI Engineering Development Unit (EDU) to evaluate design decisions, test electrical/data interfaces, develop/validate flight software, mitigate risk, and to provide a test bed for anomaly resolution for the flight model components. The EDU is intended as a risk reduction development effort and shall, as a minimum, include a flight-like Focal Plane Assembly. The Contractor shall propose the appropriate level of development and fidelity of the EDU. The Contractor shall deliver an EDU Plan with the proposal in accordance with CDRL PM-9.

Instrument Simulators Development

The Contractor shall design, develop, integrate and test the OLI Interface Simulator and the OLI Simulator. The Contractor shall ensure that the OLI Interface Simulator and the OLI Simulator meet their respective requirements as defined in the OLI Requirements Document.

Instrument Simulators - Review and Documentation Requirements

The Contractor shall report the OLI Interface Simulator and OLI Simulator status, issues, and anomalies in Engineering Peer Reviews, the PDR, and CDR reviews and review packages.

The Contractor shall provide all design and specification documentation used as the basis for development of the Instrument Simulators, which are defined as the OLI Interface Simulator and the OLI Simulator. The Contractor shall deliver for both of the Instrument Simulators:

Instrument Simulator Specification, CDRL SE-21

Instrument Simulator Users Guide, CDRL SE-22

Instrument Simulator Interface Verification Report, CDRL SE-23

Instrument Simulator Test Plan, CDRL SE-24

Instrument Simulator Software Test Reports, CDRL SE-25

Instrument Interface Simulator Specification, CDRL SE-26

Instrument Interface Simulator Users Guide, CDRL SE-27

Instrument Interface Simulator Interface Verification Report, CDRL SE-28

Instrument Interface Simulator Interface Verification Plan, CDRL SE-29

Instrument Interface Simulator Software Test Reports, CDRL SE-30

Engineering Analyses and Reports

The Contractor shall develop and deliver the following items in accordance with the CDRL SE-17, Analyses Reports:

Thermal Analysis Report

Structural and Mechanical Subsystem Performance and Analysis Report

Stress Analysis Report

Jitter Analysis Report

Radiometric Analysis Report

The Contractor shall deliver an Electrical Systems Requirements Document in accordance with CDRL SE-18.

The Contractor shall perform the necessary engineering analyses to assure that all requirements of this contract are accomplished successfully and on time. The Contractor shall perform, at a minimum, the following engineering analyses:

1. Analog amplifier analysis (stage-by-stage, each channel to include SNR, bandwidth, gain, stability, etc.)
2. Analysis of bearing-to-housing fits, tolerances, thermal effects
3. Torque analyses for all motors, torsional springs, and mechanisms.
4. Signal Integrity Analysis of all electronics cards in which the level of detail is consistent with the speed of the logic families selected in relation to the transmission line characteristics of the physical implementation.
5. Modal analysis showing survival of boards and components.

Fabrication, Assembly, and Test

The Contractor shall provide all necessary personnel, facilities, services, and materials to fabricate, assemble, and test the OLI in accordance with its design specifications.

iFabrication in this sense also includes procured items. The Contractor shall make available for review by the Government test and acceptance reports for all subcontracted and purchased items. The Contractor shall develop and provide Focal Plane Array Documentation in accordance with CDRL SE-10

Flight Software

Software Definitions

Flight Software Element

Flight Software (FSW) for the OLI includes embedded real-time software, flight firmware found in the on-board microprocessor(s) and embedded in the various OLI hardware subsystems. Functions provided by the FSW include but are not limited to: real-time operating system, time management, instrument processing, telemetry monitoring, command storage and execution, failure detection and correction, and

memory management. Flight Software also encompasses all non-deliverable, on-board microprocessor(s) software used in support of testing the Flight Software Element.

The Contractor shall treat the software component of firmware, which consists of computer programs and data loaded into a class of memory that cannot be dynamically modified by the computer during processing (including Programmable Read-Only Memories (PROMs), programmable logic arrays, digital signal processors, Field Programmable Gate Arrays (FPGAs), etc.) as flight software for the purposes of this SOW. For any autogenerated software from databases, models or other sources, the Contractor shall consider these sources as Flight Software for the purposes of this SOW.

For all flight software elements, the Contractor shall demonstrate compliance with the NASA Software Engineering Requirements specified in the NPR 7150.2 and GSFC-STD-1000, Rules for the Design, Development, Verification, and Operation of Flight Systems. These documents provide the minimal set of requirements established by the Agency for software acquisition, development, maintenance, operations, and management. The Contractor shall implement MAR requirements with respect to Software Assurance.

The Contractor shall develop, verify, validate and maintain the complete FSW image in the OLI and associated testbeds for the duration of the contract.

Software Development and Validation (SDV) Software Element

The Contractor shall develop the Software Development and Validation software for the OLI which supports the development and test of the Flight Software. It includes host development computer operating systems, high-level language compilers and debuggers, autocode generator software systems, machine language emulators, and test scenarios and procedures. It includes the software in the OLI test environment simulators that model the detectors and mechanisms. It also includes development support software such as document and code configuration management systems.

Software Criticality Classification

The Contractor shall classify all OLI software within the Flight and SDV Elements as belonging to one of the following criticality classifications and shall define the management approach of each class in the Software Management and Development Plan (SMDP) (CDRL SW-8):

- (a) Mission Critical
- (b) Mission Support
- (c) Engineering Analysis
- (d) Commercial

(d)1. Commercial software acquired for integral use within planned operational elements shall be assigned a criticality equal to that of the element of which it is a part.

These software classifications are defined in the LDCM Acronym List and Lexicon (LDCM-xxxx). (TBD)

The Contractor shall classify all LDCM software within the Flight and SDV Elements as belonging to one of the following types of software and shall define the management approach of each class in the Software Development and Management Plan (SDMP):

- (a) Developed
- (b) Reuse
- (c) Heritage
- (d) Off-the-Shelf (OTS)

(d)1. OTS software is further defined as Commercial-Off-the-Shelf (COTS), Modified-Off-the-Shelf (MOTS) software, and Government-Off-the-Shelf (GOTS) software.

These software types are defined in the LDCM Acronym List and Lexicon (LDCM-xxxx) (TBD).

The Contractor shall meet the requirements of NASA Software Engineering Requirements specified in the NPR 7150.2 when choosing to use OTS software to satisfy all or part of the software requirements implementation. The details of OTS utilization and management of such shall be provided in the Contractor's SDMP.

Software Management, Requirements, Development, Verification, and Testing

The Contractor shall document in the Software Development and Management Plan (SDMP) document, in accordance with CDRL SW-8, the software management approaches and processes for software analysis, design, development, documentation, version control, test, validation, risk management, metric collection, and assurance of all software products. The Contractor shall adhere to the SDMP.

Planning and Requirements Life Cycle Activities

The Contractor shall perform all analyses and software systems engineering required to identify and allocate (from system and subsystem requirements) software requirements and shall generate the Software Requirements Specification (SRS) in accordance with CDRL SW-1. The Contractor shall ensure that all requirements are forward and backward traceable between system and software requirements and between software requirements, design, and test.

The developer shall plan and implement a Verification and Validation (V&V) program to ensure that software being developed or maintained satisfies functional and performance requirements defined in the SRS. The Contractor's testing approach and methodology shall be documented in the Software Test Plan in accordance with CDRL SW-6 program. The Contractor shall address the approach to the following levels of testing on the flight software elements as identified in the Flight Software Test Plan:

V&V of the logic of individual software functions while exercising all critical paths of

the software unit.

V&V of an integrated FSW build delivered to the FSW Test Team operates as designed and meets each functional and performance requirement allocated to the build.

V&V of the FSW in its target hardware environment in a manner as close as possible to post-launch operations with the intent of qualifying the FSW as a mission subsystem ñ meeting all on-orbit nominal, anomalous and contingency operational requirements.

For the purposes of the SOW, Acceptance testing is defined as the formal execution of a full set of FSW System Validation Tests against the final delivery of the FSW system.

The Contractor shall identify how all non-flight code resident in flight hardware is identified, and how its inadvertent or deliberate execution is absolutely prevented after launch.

Design Life Cycle Activities

The Contractor shall maintain Algorithm Design Documents (ADD) for each OLI subsystem that incorporates flight software in its implementation. The Contractor shall deliver the Software Design Document and Software Users Guide in accordance with CDRLs SW-2 and SW-3.

Implementation and Delivery Life Cycle Activities

The Contractor shall implement the documented Hardware and Software Configuration Management Plan (CDRL PM-10) with respect to Flight Software Development and Test. All software elements (flight and ground test) shall be placed under Configuration Management, including default and baseline values for tables and parameters used in the Ground Test Software and Flight Software.

To assist in the verification and validation of software requirements, the Contractor shall develop and maintain a Software Requirements Verification Matrix (SRVM). The SRVM shall be available to the government upon request.

The Contractor shall ensure that all deliverable computer systems show the following splash screen on initial turn-on, exiting of which shall require specific keyboard action by the operator (e.g. CTRL-ALT-DEL):

This system is for the use of authorized users only. By accessing and using this computer system you are consenting to system monitoring, including the monitoring of your keystrokes. Unauthorized use of, or access to, this computer system may subject you to disciplinary action and criminal prosecution.

The Contractor may enhance the display as appropriate, maintaining readability.

The Contractor shall capture and maintain detailed testing procedures. Electronic versions of test procedures shall be available upon request to the government. The Contractor shall document, verify and validate Formal Software Tests through the Software Test Report in accordance with CDRL SW-5.

In the software acceptance test phase, the Contractor shall prepare for formal monitoring

and/or auditing of software testing by Government personnel to include the NASA IV&V staff. Upon successful completion of this phase of testing, the Contractor shall close out all major action items, present a plan to resolve all residual actions, and prepare for formal delivery of the software.

The Contractor shall identify in the SRVM Flight software requirements which require flight hardware in the loop that shall be verified and validated during instrument and/or Observatory I&T testing. These tests shall include, but are not limited to, assuring correct polarity, phasing, mechanism direction and symmetry, index positions, gains, scale factors, and some failure detection and correction actions.

The Contractor shall ensure that both functional and performance test procedures execute the OLI flight software in all modes and configurations using the OLI flight hardware. The Contractor shall perform these tests on both primary and at least one redundant configuration. These tests will be used to verify performance during initial integration, environmental testing, pre-ship at the Observatory integration facility, post-ship at the launch facility, and on the launch vehicle. The Contractor shall design these tests to execute as much of the flight software code and data as is practical prior to launch.

Software Management Requirements Software Measures (Metrics)

The Contractor shall acquire and include Software Measures (Metrics) as defined in the SDMP from any sub-contractors or team members.

The Contractor shall collect and report software measures supporting the analysis of both software product quality and schedule/effort/cost performance. The collection and reporting of metrics shall be automated to the fullest extent practical. Measures shall be provided to the Project both as raw data and in graphical form as part of the monthly status review

Software Reviews

The Contractor shall prepare and conduct flight software status reviews as part of the technical status portion of the Monthly Project Status Reviews as described in SOW Section 1.2.3.2.

Software TIMs shall be conducted with Government participation.

In addition to the Engineering Peer Reviews (EPRs) listed in SOW section 1.2, the Contractor shall conduct the following software-specific EPRs:

Software Requirements EPR
Software PDR EPR
Software CDR EPR
FSW Acceptance Test Readiness Review (ATRR) and deliver a Software Test Readiness

Review Data Package in accordance with CDRL SW-4 Software Acceptance Review (SWAR) and deliver a Software Acceptance Review Data Package in accordance CDRL SW-5.

NASA IV&V Support

The Contractor shall ensure that all software documentation and code required for the NASA Software Independent Verification and Validation (IV&V) effort is made available to NASA IV&V personnel. This includes access to all software reviews and reports, developer plans and procedures, software code, software design documentation, and software problem reporting data. Wherever possible, the Contractor shall permit electronic access to the required information or furnish soft copies of requested information to NASA IV&V personnel.

The Contractor shall review and assess all NASA IV&V findings and recommendations. The Contractor shall forward their assessment of these findings and recommendations to the LDCM Project Office. The Contractor shall take necessary corrective action based upon their assessment and notify the LDCM Project Office of this correction action. The Contractor shall also notify the LDCM Project Office of those instances where they decided not to take corrective action on specific IV&V findings and recommendations. A Contractor point of contact shall be assigned and available to NASA IV&V personnel, as required, for questions, clarification, and status meetings.

Software Maintenance

The Contractor shall develop and maintain the OLI Flight software and documentation, along with the environments, emulators, and test software necessary to develop and verify these systems through the duration of the contract.

The Contractor shall develop, certify, and maintain the Software Development and Validation Facility (SDVF), which is a real-time closed loop flight software test bed facility. The Contractor shall develop the requirements of the SDVF and present these requirements and their rationale at the Software Requirements EPR. The Contractor shall keep the SDVF at their facility for the duration of the contract period.

The Contractor shall maintain any special hardware (non-commercial such as C&DH components and power supplies) in the SDVF for the duration of the contract.

In the event of transition of software maintenance to another entity, the Contractor shall deliver the SDVF to the Government.

The Contractor shall demonstrate delivery of a flight software patch from the Contractor facility to the Government MOC prior to the Operations Readiness Review.

The Contractor shall deliver the Software Delivery Package and Updates in accordance

with CDRL SW-7.

Instrument Integration and Test

The Contractor shall use Integration and Test discipline expertise throughout the product lifecycle.

Integration

The Contractor shall integrate the instrument assemblies into a fully assembled OLI that is ready for performance and environmental testing.

Environmental and Performance Testing

The Contractor shall provide all personnel, facilities, services, and materials necessary to verify that the OLI meets its functional and performance specifications after exposure to the environments required by the LDCM Environmental Verification Requirements (427-XXX) (TBD 2).

The Contractor shall develop and deliver the Environmental Verification Plan and Environmental Test Matrix in accordance with CDRL IT-6.

The Contractor shall develop and deliver an Instrument Integration and Test Plan in accordance with CDRL IT-1.

The Contractor shall execute the approved Environmental Verification Plan and the approved Integration and Test Plan using the fully integrated OLI subsystems in as near a flight-like mechanical configuration as is practicable, and operating the launch, safe-hold, and nominal configurations, as appropriate.

The Contractor shall develop and deliver Detailed Test Plans in accordance with CDRL IT-3.

The Contractor shall develop and deliver Test Reports in accordance with CDRL IT-2.

The Contractor shall provide Verification Reports in accordance with CDRL SE-7.

The Contractor shall deliver Instrument Data Sets in accordance with CDRL CV-9.

The Contractor shall document and investigate anomalies and perform anomaly resolution. The Contractor shall notify the Government of anomalies within 24 hours of occurrence. The Contractor shall store and maintain all output data collected during testing for anomaly resolution. Anomaly resolution is the identification, investigation, and resolution of anomalies including the characterization of a problem or deficiency, determination of the probable cause or missing functionality, evaluation against existing specifications and requirements, and providing analysis to the Government for prospective corrective actions or enhancements.

The Contractor shall allow Government personnel access to all released and as-run test

procedures, test conductor log books and electronic command logs; testing; and test planning meetings.

The Contractor shall deliver the As-Run Test Procedures in accordance with CDRL IT-5.

The Contractor shall maintain, calibrate, and certify Ground Support Equipment (GSE) to Contractor standards.

Instrument Calibration

The Contractor shall develop and provide the Calibration and Validation Plan in accordance with CDRL CV-1. The Contractor shall implement the Calibration and Validation Plan. The Contractor shall calibrate the OLI in accordance with the Government-approved Contractor-developed Calibration and Validation Plan. The Contractor shall implement the requirements of the Special Calibration and Test Requirements Document. The Contractor shall provide Calibration/Validation Procedures, for every calibration/validation test described in CDRL CV-1, in accordance with CDRL CV-2. The Contractor shall provide Calibration/Validation Reports in accordance with CDRL CV-3. The Contractor shall provide Calibration/Validation Summary Reports in accordance with CDRL CV-3. In addition, the Contractor shall provide Relative Spectral Response (RSR) Component Measurements and System RSR Analysis in accordance with CDRL CV-8. The Contractor shall provide spectral filter witness samples that were fabricated at the same time, using the same process, as the flight spectral filters, and are a minimum of one-inch diameter, to the Government in accordance with Contract attachment B.1.

Instrument Independent Testing

To maintain continuity of the Landsat data archives and calibration to the National Institute of Standards and Technology (NIST), the Contractor shall provide access to the Contractor's radiometric calibration sources sufficient for the Government and Government contractors to conduct source characterization at the Contractor's facility. The Contractor shall also provide coordination and support sufficient for the Government and/or its Contractors to conduct independent pre-launch measurements of the Contractor's radiometric calibration sources at the Contractor's facility.

For Government Transfer Radiometer testing, the Contractor shall provide access sufficient for the Government and/or its Contractors to conduct source characterization in the Contractor's laboratory environment. For planning purposes this shall be assumed to consist of a total of five 2-day periods: three 2-day periods prior to sensor calibration; and two 2-day periods after sensor calibration. In addition, the Contractor shall provide access sufficient for the Government and/or its Contractors to conduct source monitoring during Sensor calibration activities.

The Contractor shall provide access and support for NIST/Earth Observing System (EOS) radiometric scale realization activities. For planning purposes this shall be assumed to consist of two 4-day periods: one prior to sensor calibration with the calibration source and one after sensor calibration,. The radiometric scale realization

activities will involve viewing of the radiometric calibration source(s), typically large aperture integrating spheres, used by the Contractor to calibrate the OLI. These sources will be viewed by a number of transfer radiometers and the results will be compared to the Contractor's calibration of this source. The Contractor shall supply access to and an operator for the radiometric calibration source as well as the current radiometric calibration of this source.

The Contractor shall account for these Independent Testing periods of access in the contract and program schedule. The Government will provide reasonable notice of these periods of access.

Instrument Operations Support

Support to Mission Operations Element Development

The Contractor shall support the Government's development of the LDCM Mission Operations Element (MOE) by reviewing and providing comments on MOE documentation related to instrument command and telemetry.

Operational Procedures and Documentation

The Contractor shall develop and provide the following CDRLs:

CDRL SE-14, Instrument Concept of Operations Document

CDRL OO-5, OLI Launch Commit Criteria

CDRL OO-7, OLI Launch and Early Orbit Procedures

CDRL OO-8, OLI On-Orbit Operations and Contingency Procedures

CDRL OO-10, OLI Constraints, Restrictions, and Warnings Document

The Contractor shall verify operations procedures on the instrument hardware prior to approval. The Contractor shall verify contingency procedures on the instrument hardware or instrument simulators prior to approval. The Contractor shall perform the software translation of these procedures from the test software/hardware environment to the operational software/hardware environment that will exist in the MOE. The Contractor shall review and provide inputs to Observatory-level procedures, including: Launch and Early Orbit, nominal, contingency, and satellite reconfiguration procedures.

Command and Telemetry Database Support

The Contractor shall supply the OLI Telemetry and Command Database, including stored and real-time commands for both nominal and non-nominal/contingency operations in accordance with CDRL OO-11. The Contractor shall support the Government in conversion of instrument command and telemetry databases for use in the Mission Operations Element. The Contractor shall provide the Instrument Telemetry and Command Handbook in accordance with CDRL OO-6. The Contractor shall place the telemetry and command database under formal configuration management.

Training Support

The Contractor shall provide training material to support Flight Operations Team training. The Contractor shall provide the OLI Training Materials in accordance with CDRL OO-9. The Contractor shall train up to twenty Flight Operations Team (FOT) participants and shall use as a basis, the Instrument Users Manual (OO-2). The Contractor shall prepare and provide all course materials, and conduct a two-day (16 hours) Flight Operations Team training class at the MOC facility. The Contractor shall provide two training sessions: one for the OLI instrument and one for the OLI Simulator. The Contractor shall also provide an additional identical set of training sessions for the FOT just prior to launch.

The Contractor shall recommend to the Government which activity(s) in the instrument integration and test flow would provide the best opportunity to introduce the Flight Operations Team to instrument operations through observation of I&T activities. The Contractor shall allow the FOT access to observe these activities on a non-interference basis.

Packaging, Handling, Storage, and Transportation

The Contractor shall prepare, pack, and ship all OLI subsystems, systems, and the simulators between the places of manufacture, and integration and test, and storage and delivery in appropriate shipment containers. The Contractor shall prepare, pack, and ship all related GSE required to support OLI subsystems, systems, and simulators during each phase of test, integration and launch preparation. The Contractor shall develop a Packaging, Handling, Storage, and Transportation (PHS&T) Plan and Procedures in accordance with CDRL IT-4 and shall ship the appropriate OLI systems, subsystems, and simulators and all related GSE in accordance with the Plan. The Contractor shall perform a complete post shipment functional test of the OLI systems, subsystems, simulators, and all related GSE. The Contractor shall plan and support all activities necessary to safely ship the integrated LDCM Observatory and required OLI GSE, if any, to the launch base. The Contractor shall plan and support all activities necessary to safely ship the OLI Simulator and required GSE, if any, to the MOC from the spacecraft contractor's facility.

OLI Storage

The Contractor shall, at the direction of the Government, store the OLI for a period of no more than one year prior to delivery to the spacecraft contractor's facility. If so directed, the Contractor shall implement the storage plans developed under CDRL IT-4.

Delivery, Checkout, and Acceptance

The Contractor shall provide the personnel, facilities, and hardware necessary to prepare and pack the OLI and its GSE for shipment, and shall be responsible for the transportation and shipment of the material to the designated spacecraft facility. The Contractor shall unpack the flight hardware and GSE upon its arrival at the spacecraft

contractor's facility, perform a visual inspection to detect physical damage, set up a bench test environment, and perform a post-delivery functional check out of OLI. The spacecraft contractor will provide facilities, security, storage, standard cleaning supplies, and standard test equipment (multimeter, probes, grounding, ionized air, etc.). The Contractor shall provide a bench check-out test report including comparison to the identical pre-ship test performed at the Contractor's facility.

Government conditional acceptance will occur after successful completion of post-delivery checkout. The Contractor shall deliver an Acceptance Data Package in accordance with CDRL SE-20. The Contractor shall be responsible for the OLI handling and operation from delivery until lifted ion-hooked by the spacecraft contractor for mechanical integration with the spacecraft. The spacecraft contractor will be responsible for maintaining and controlling a safe environment for all OLI hardware and personnel from the time of arrival at the spacecraft contractor's facility until delivered to the launch site, or ready to ship for return to the OLI Contractor, as directed by the Government.

Ground Support Equipment Calibration Test Equipment

The Contractor shall define, design, build, provide, maintain, transport, and document all equipment necessary to radiometrically, spectrally, and geometrically calibrate the OLI. The Contractor shall perform tests necessary to demonstrate that all Ground Support Equipment (GSE) is functioning properly and within specification.

Mechanical GSE

The Contractor shall define, design, build, provide, maintain, ship, and document, as necessary, the mechanical GSE. Mechanical GSE consists of equipment and fixtures required to operate, test, handle, lift, perform optical alignment, and maintain the OLI, at the Contractor's facilities and at the spacecraft contractor's facilities. Mechanical GSE also includes equipment required to provide the appropriate thermal and vibration test environments at the Contractor's facilities as specified in the LDCM Environmental Verification Requirements. The Contractor shall provide OLI instrument protective covers that protect fragile components from minor impact as well as contamination. The Contractor shall provide instrument drill templates to the Government to be used by the spacecraft contractor to correctly place the instrument-mounting interface on the spacecraft.

Electrical GSE

The Contractor shall define, design, build, provide, maintain, ship, and document, as necessary, the OLI electrical GSE throughout the duration of the contract. The electrical GSE consists of the System Test Equipment (STE) and software necessary to command, monitor, and test the OLI at the Contractor's facilities and at the observatory level to support all applicable testing (Comprehensive Performance Tests, Limited Performance Tests, environmental testing, end-to-end tests, etc.), as required.

Shipping, Storage, and Purge Equipment

The Contractor shall provide environmentally controlled shipping and storage containers and necessary ancillary equipment, including shock recorders, for shipment of the OLI to the spacecraft contractor's facility.

The Contractor shall provide shipping and storage containers, and necessary ancillary equipment, as required, for shipment of the OLI Simulator to the spacecraft contractor's facility, and to the MOC.

The Contractor shall pack and ship all flight hardware, GSE, test equipment, and support equipment as required.

Spares

The Contractor shall define and implement a spares program appropriate to minimize delivery schedule impact created by failures, contamination, or by other plausible events or conditions for all flight and ground support equipment. The Contractor shall provide a Spare Parts Plan and List in accordance with CDRL SE-19. The Contractor shall qualify, test, and calibrate flight spares to the same level as the corresponding flight parts.

Post-Delivery Support

Observatory Integration and Test

The Contractor shall provide all personnel, equipment, services, and materials necessary to test the OLI instrument at the observatory level of assembly, and to support observatory integration and testing. The majority of this support shall be provided on-site at the spacecraft contractor's facilities. Contractor-provided equipment shall include all GSE, intra-instrument test tees, interrupt boxes, and breakout boxes. For planning purposes, the Contractor shall assume that observatory launch readiness date is 10 months after instrument delivery.

Interface Testing

The Contractor shall provide all personnel and equipment necessary to plan, conduct, and verify readiness to interface the OLI with the spacecraft. The Contractor shall provide on-site personnel as required.

Observatory Integration

The Contractor shall plan, conduct, and provide on-site personnel necessary to integrate the OLI to the spacecraft. The Contractor shall perform the following, at a minimum:

Perform safe-to-mate and signal characterization tests on all instruments and GSE prior to electrical mating.

Assist and provide advice during OLI-related integration activities and testing conducted

by the spacecraft contractor, including alignment and thermal blanket close-outs. Review and provide inputs to the OLI to spacecraft integration procedure.

Observatory Testing

The Contractor shall plan, analyze, and verify OLI performance at spacecraft ambient and environmental conditions in accordance with the contractor-generated System Performance Verification Plan. The Contractor shall provide on-site personnel on a 24/7 basis during spacecraft thermal vacuum testing. In addition, the Contractor shall provide personnel during other key spacecraft tests as defined by the Government. The Contractor shall provide personnel at the spacecraft contractor's facility to monitor the OLI whenever the OLI is powered on. The OLI instrument will not be powered or operated on the spacecraft at any time without the Contractor I&T support staff present, concurring, and actively participating. The Contractor shall assume spacecraft thermal vacuum testing is eight weeks in duration. The Contractor shall provide on-site data analysis for all testing involving the instrument. The Contractor shall perform the following, at a minimum:

Provide on-site support of all performance testing, including real-time monitoring and off-line data analysis, of the instrument after integration on the spacecraft, covering all shifts worked by the spacecraft contractor.

Provide personnel to review procedures, provide expertise, witness testing, and interpret data before, during, and after OLI-related ambient and environmental testing conducted by the spacecraft contractor.

Provide conversion of instrument GSE command and telemetry procedures for use in spacecraft GSE. Format is to be supplied by the spacecraft contractor.

Support and conduct anomaly investigations involving the OLI and implement corrective actions.

The Contractor shall connect GSE to the OLI during Observatory I&T only on an as-needed exceptional basis for anomaly troubleshooting.

Mission Interface Testing and Rehearsal Support

Support to End-to-End Test(s)

The Contractor shall support Space Segment to Ground End-to-End testing. The Contractor shall demonstrate that the instrument science data can be processed to Level 0. The Contractor shall demonstrate that Level 1 data can be produced with the raw image data using simulated attitude and ephemeris data. The Contractor shall support and participate in every end-to-end test conducted prior to observatory shipment to the launch site. The Contractor shall:

Participate with the Government in devising the test goals, requirements, and success criteria

Conduct reviews of the commands, telemetry, procedures, scripts, contingency plans, etc. to be used in the testing

Participate in a test readiness review approximately one week prior to the performance of each test that covers the test plan, procedures, scripts, and test support and coordination activities.

Participate in test execution and generate data products, if required.

Participate in post-test analysis of results.

Resolve instrument anomalies and incorporate lessons learned for future tests

Support to RF Compatibility Testing

The Contractor shall participate in planning for Radio Frequency (RF) Compatibility Tests between the Observatory and the NASA RF interface equipment (e.g., NASA Compatibility Test Van or other equipment). The OLI will be operated during RF Compatibility Testing to demonstrate compatibility and to provide a data stream.

Support to Launch Rehearsals and Exercises

The Contractor shall assist in planning and participate in a minimum of three launch rehearsals. The third Launch Rehearsal is a full dress rehearsal and includes participation by all LDCM Space, Ground, and Flight Operations segment personnel and resources required to conduct LEO activities. The launch rehearsals will demonstrate nominal execution of timelines as well as simulated anomaly/contingency response scenarios.

In addition, the Contractor shall participate in five training exercises with the Government provided FOT team to simulate typical day-in-the-life on-orbit Observatory operations. The exercises will simulate day-in-the-life scenarios that include exercise of nominal command and control operations, instrument tasking, state-of-health (SOH) procedures, and anomaly recovery operations.

For these exercises and launch rehearsals, the Contractor shall participate in:

Devising the goals and resource requirements

Reviews of planned activity with participants

Executing the activity and collecting appropriate data

Post-activity debriefs and lessons learned review with participants

Generating a post activity report that documents the outcome of rehearsal activities.

Resolving anomalies and incorporating lessons learned into future activities

Instrument Simulators Checkout, Acceptance, and Support

OLI Simulator

After shipment of the OLI Simulator and its GSE to the spacecraft contractor's facility, and also after shipment to the MOC, per SOW paragraph 4.4, the Contractor shall perform a complete post shipment functional test of the OLI Simulator and all GSE after each shipment. The Contractor shall provide expertise and on-site support for the

integration of the OLI Simulator to the spacecraft simulator. The Contractor shall be responsible for the OLI Simulator operation at all times, including after integration with the spacecraft simulator. The spacecraft contractor will be responsible for maintaining and controlling a safe environment for all OLI hardware and personnel from the time of arrival at the spacecraft contractor's facility until delivered to the MOC, as directed by the Government.

The Contractor shall be present, concurring and actively participating whenever the OLI Simulator is powered or operated.

The Government will accept the OLI Simulator after it successfully passes its acceptance test following delivery to the MOC. The Contractor shall prepare an Acceptance Data Package in accordance with CDRL SE-20.

OLI Interface Simulator

After shipment of the OLI Interface Simulator and its GSE to the spacecraft contractor's facility, the Contractor shall perform a complete post shipment functional test of the OLI Interface Simulator and all GSE after each shipment. The Contractor shall be responsible for the OLI Interface Simulator operation until successful integration with the spacecraft simulator.

The Contractor shall provide expertise, hands-on training, and on-site support for the integration of the OLI Interface Simulator to the spacecraft.

The Government will accept the OLI Interface Simulator after it is successfully tested with the spacecraft. The Contractor shall prepare an Acceptance Data Package in accordance with CDRL SE-20.

Launch Support

Launch and Early Orbit Support

The Contractor shall conduct post-shipment instrument checkout at the payload processing facility in accordance with the Integration and Test Plan, as appropriate.

The Government will maintain and control a safe environment for all OLI hardware and personnel from the time of arrival at the payload processing facility through launch.

The Contractor shall participate in launch preparations and provide launch site and Mission Operations Center (MOC) launch support, providing all necessary personnel, services, and materials.

The Contractor shall participate in launch, Observatory deployment, instrument activation including deployments, and early on-orbit activation activities performed from the Government-provided MOC.

Commissioning, including On-Orbit Check-out

Commissioning is the series of events after spacecraft and instrument activation that includes instrument checkout and performance verification prior the start of nominal LDCM operations. The Contractor shall perform whatever actions required to place the OLI in an operational state prior to the end of commissioning. At the end of the commissioning phase, the Government will determine if the OLI is ready for nominal operations.

Instrument Checkout

The Contractor shall perform post-launch verification and test of the OLI.

The Contractor shall perform instrument checkout at the Government-provided MOC, providing all necessary personnel, services, and materials.

A Government-provided Flight Operations Team, trained and certified by the Contractor, will execute all instrument commands as expressly authorized by the Contractor.

The Contractor shall complete OLI checkout within 90 days after launch, providing all necessary personnel, services, and materials.

The Government will provide to the Contractor a list of World Reference System^{ñ2} (WRS-2) scenes that will be used by the Government for independent validation of image quality. Included in this list will be scenes to be imaged off-nadir. The FOT will acquire data for each of these scenes within 60 days after launch.

From these Government-provided scenes, and using Contractor-generated algorithms, the Contractor shall provide data products that demonstrate compliance with specifications. The Government will furnish ground control points and digital elevation models for these scenes. The Government will provide to the Contractor the Level 0 data for all acquired scenes.

The Contractor shall assist the Government in reconciling any differences in data product results between results derived from Contractor-provided algorithms and results derived from Government-derived operational algorithms.

The Contractor shall, at a minimum:

Provide an OLI On-Orbit Commissioning Plan in accordance with CDRL OO-1.

Determine the duration of the instrument outgassing period and monitor outgassing effectiveness during commissioning phase.

Provide OLI On-Orbit Test and Calibration/Validation Procedures in accordance with CDRL OO-12.

Review and analyze OLI post-launch test data and provide On-Orbit Test Reports in

accordance with CDRL OO-3.

Conduct OLI post-launch pre-Initial Operational Capability (IOC) validations in accordance with the System Performance Verification Plan (SPVP).

Conduct tests in accordance with the Special Calibration Test Requirements Document.

Participate in Observatory activity planning, including, but not limited to, schedule planning and Observatory maneuver requirements related to completion of Special Calibration Test Requirements (SCTR) activities.

Calibrate the OLI and determine the OLI calibration parameters.

Investigate and resolve on-orbit anomalies that affect OLI specification-related performance parameters and/or anomalies that threaten OLI health and safety.

Provide an On-orbit Anomaly Resolution Support Plan in accordance with CDRL OO-4.

The Government will conduct a full 16-day *operational* imaging cycle prior to Acceptance.

Handover

The Contractor shall participate in the handover of full Observatory control to the Government after successful demonstration of observatory performance, at which time the Government assumes responsibility for the health and safety of the Observatory.

In a non-nominal launch or commissioning situation, the Contractor shall provide engineering and operations support until Government acceptance or disposition. For planning purposes, the Contractor shall assume this engineering and operations support will be 3 months in duration and, if required, will be performed in lieu of the nominal commissioning phase activities.

Engineering Support

Nominal Operations

The Contractor shall provide the following services after Government acceptance through the period of performance of the contract:

Maintain the Instrument EDU components as a tool for resolving on-orbit anomalies. Prior to the end of the contract period, train the Government Flight Software (FSW) Maintenance Team on maintenance of FSW in preparation for transition of FSW maintenance to the Government.

Participate in a joint LDCM Configuration Control Board with the Government. Assume one telecon meeting per month of one-half day duration starting at the end of the commissioning phase.

Maintain the Instrument Simulator.

Task Support

The Contractor shall perform tasks relating to the continued on-orbit support of LDCM, as authorized by the Government and in accordance with contract clause XX (TBD 4).

Each task will be initiated by written direction from the Government contracting officer. The Government will coordinate with the Contractor to define each task in detail, and establish manpower ceilings, performance schedules, and deliverables.

These Government-initiated tasks will include the following :

Support post-Commissioning operations as required. This support can include: supplying technical expertise to perform analyses, to review data, or to review changes to documentation.

Investigate on-orbit anomalies that affect specification-related performance parameters and/or anomalies that threaten OLI health and safety and provide recommendations for resolution.

The Contractor shall acknowledge notification of the anomaly and provide an initial action plan within 12 hours of notification by the Government. The Government will follow up with written direction and coordinate the task details as soon as possible.

An action plan describes the activities intended to support the anomaly investigation.

Maintain flight software and provide updates to flight software to provide capabilities requested by the Government.

Provide technical documentation, installation procedures, on-orbit validation procedures and back-out procedures

Provide calibration and validation consultation support to the Government on an as-needed basis.

Participate as necessary in the Decommissioning Review prior to decommissioning of the observatory at end-of-life.

Optional Extended Support

If the Government exercises the optional one-year extensions of on-orbit support in accordance with Contract Clause XX (TBD 5), the Contractor shall perform the following during the option period.

Nominal Operations

The Contractor shall provide the following services:

Maintain the Instrument EDU components as a tool for resolving on-orbit anomalies. Prior to the end of the contract period, train the Government Flight Software (FSW) Maintenance Team on maintenance of FSW in preparation for transition of FSW maintenance to the Government.

Participate in a joint LDCM Configuration Control Board with the Government. Assume one telecon meeting per month of one-half day duration.

Maintain the Instrument Simulator.

Task Support

The Contractor shall perform tasks relating to the continued on-orbit support of LDCM, as authorized by the Government and in accordance with contract clause XX (TBD 4) (TBD 5? Different clause?). Each task will be initiated by written direction from the

Government contracting officer. The Government will coordinate with the Contractor to define each task in detail, and establish manpower ceilings, performance schedules, and deliverables.

These Government-initiated tasks will include the following:

Support post-Commissioning operations as required. This support can include: supplying technical expertise to perform analyses, to review data, or to review changes to documentation.

Investigate on-orbit anomalies that affect specification-related performance parameters and/or anomalies that threaten OLI health and safety and provide recommendations for resolution.

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Maintain flight software and provide updates to flight software to provide capabilities requested by the Government.

Provide technical documentation, installation procedures, on-orbit validation procedures and back-out procedures

Provide calibration and validation consultation support to the Government on an as-needed basis.

Participate as necessary in the Decommissioning Review prior to decommissioning of the observatory at end-of-life.

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CHECK THE LDCM NGIN WEBSITE AT:

<https://ldcmngin.gsfc.nasa.gov>

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National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

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Jeanine Murphy-Morris

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 Requirements Analyses and Allocations
 Interface Definition, Verification and Control
 Design and Performance Verification
 Systems Analyses
 Trending
 Special Studies
Mission Assurance
LDCM Instrument Development
 Design Engineering
 Algorithms and Mathematical Models
 Engineering Development Unit
 Instrument Simulators Development
 Engineering Analyses and Reports
Fabrication, Assembly, and Test
 Flight Software
 Instrument Integration and Test
Instrument Operations Support
 Support to Mission Operations Element Development
 Operational Procedures and Documentation
 Command and Telemetry Database Support
 Training Support

Packaging, Handling, Storage, and Transportation
 OLI Storage
Delivery, Checkout, and Acceptance
 Ground Support Equipment
 Calibration Test Equipment
 Mechanical GSE
 Electrical GSE
 Shipping, Storage, and Purge Equipment
 Spares
Post-Delivery Support
 Observatory Integration and Test
 Interface Testing
 Observatory Integration
 Observatory Testing
Mission Interface Testing and Rehearsal Support
 Support to End-to-End Test(s)
 Support to RF Compatibility Testing
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